Evaluation of a High Resolution GEOPIG to detect and Size Slab Erosion

By, Stephen Westwood, BJ Pipeline Inspection Services, Canada

Abstract

From previous MFL Inspections of a 14” sub-sea pipeline, in-depth analysis by a pipeline operators Integrity Department identified the absence of the seamless pattern on the pipeline at various positions. These indications were typically 100’s of metres in length and covered the same o’clock positions. The presence and size of the features meant that the applied inspection technology could not successfully size these features, which complicates the pipeline integrity assessment. In connection with the integrity assessment, they needed to know the depths of the erosion features and were investigating various technologies to determine the feature depths. This paper outlines the investigation of various inspection technologies and the subsequent evaluation of the High Resolution Caliper survey as a technique for detecting and sizing slab erosion.

Introduction

The Company’s pipelines are maintained by chemical inhibition in combination with regular cleaning programmes. In addition, an extensive monitoring programme is implemented to identify precursors to internal corrosion issues, e.g. MIC. The results are analysed and combined with past inspection results to establish annual pipeline inspection programmes.

The pipeline was installed in 2002 to carry well fluids from a satellite to existing separation facilities. The pipeline went into service in 2003 and currently transports in excess of 60,000 bbls of well fluid per day. With increasing production from the launch site, there is a potential risk of erosion of the pipeline due to high flow velocities. The pipeline was inspected by an MFL tool; on receiving the final report the inspection vendor had stated that there were 2 metal loss anomalies and 11 girth weld indications in the pipeline. The operator adopted a practice of reviewing all pipeline inspection reports using a consultant qualified to review the data at signal trace detail and comment on the both the accuracy of the signal interpretation and consistency of the reporting accuracy. The review confirmed that there were no significant areas of corrosion within the pipeline, however the inspection results showed that some of the sensors recorded low-amplitude signals over large areas of the pipeline. The third-party expert review concluded that the quiet signals may be the result of slab erosion of the seamless pattern and girth welds. Examples of these effects are shown in Figure 1 and Figure 2.

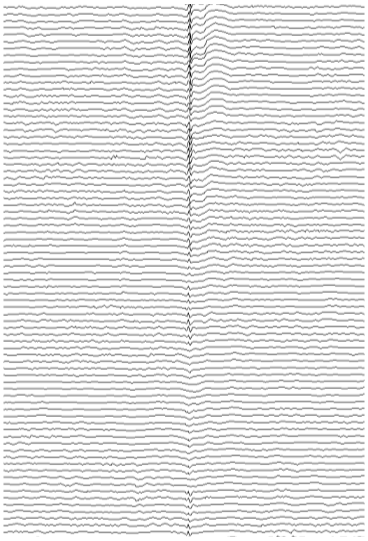

Figure 1 Showing the weld signal virtually disappear completely at some clock positions.

Figure 2 Showing the lack of seamless pattern at specific clock positions.

A review of the historical operation of the pipeline (process data) showed that on occasions the pipeline flowed at high product velocities, suggesting that slab erosion was a possibility. Because of the technical limitations of MFL technology to detect the potential metal loss and the logistical problems of running a UT tool, BJ Pipeline Inspection Services looked for a novel approach in measuring any metal loss that may have occurred within this pipeline.

Comparison of Current ILI Technologies for Slab Erosion

The two prevalent in line inspection techniques for finding metal loss are ultrasonic's and magnetic flux leakage. These techniques have strength and weakness depending on the pipeline to be inspected and the type of metal loss that occurs in the pipeline.

Ultrasonic tools work by transmitting a sound wave perpendicular to the pipe wall. This wave reflects of the front wall and the back wall. The time taken for the transmission of the sound is related to the wall thickness of the material. Therefore the technique is an absolute measure of wall thickness. The biggest drawback with this technique is the need for a couplant between the sensor and the pipewall, without this couplant the wall thickness cannot be determined. Typically ultrasonic tools are run either in liquid product or in a liquid slug in a gas pipeline.

For an offshore pipeline the use of a liquid slug introduces a costly overhead onto the inspection cost.

Magnetic Flux Leakage Tools do not need a couplant for them to work. The technique is however not an absolute measurement of the wall thickness it is an inferred measurement. The pipe steel is magnetised and any leakage from a defect is recorded and translated into percentage wall loss by a sizing algorithm. The technique is very sensitive to detecting local areas of metal loss, however as the size and extent of the defect increases its ability to detect and size the corrosion decreases. For areas like the slab corrosion the operator expected it is unlikely that a MFL tool would be able to size the corrosion correctly.

Investigation into Alternative techniques

Given the need for a liquid slug for a successful ultrasonic inspection and its prohibitive cost and the fact that a MFL inspection would not likely be successful, the operator started to investigate alternative inspection techniques. Various In Line Inspection companies were asked to provide alternative inspection techniques and these were evaluated in a paper exercise. Based on the result of this exercise, they decided to investigate the potential of using a High Resolution Caliper to inspect, detect and size slab corrosion.

The concept behind this was that a caliper tool can measure the diameter of the tool at multiple points around the circumference of the pipeline. The diameter where the slab erosion would be present would increase and then could be sized. The depth of the slab erosion, its length and its circumferential extent could be sized.

Tool Description

The electronics of the 12" Caliper tool is capable of handling 42 calipers with 12 bit resolution sampling at 1000Hz. When comparing between measured caliper deflection and sampled data, the deflection difference is less than 1mm. Such accurate data allows the tool to travel at high speed and yet maintain accuracy in ovality measurement. Data integrity is ensured by implementing two's complement checksum and data storage is minimized by implementing data compression during real time data processing. The Inertial Measurement data stream from the Ln200 is recorded at 400Hz to allow accurate positional and bending strain data to be generated.

The schematic of the tool is shown in Figure 3, the first module contains the electronics and the caliper arms, the second module contains the inertial measurement unit and the third module contains the battery.

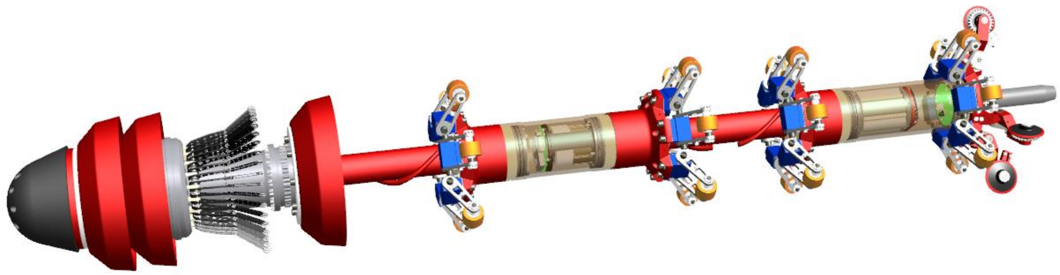

Figure 3 Schematic of the 12" High resolution Geopig Tool

PullTest Results

Two sets of pulltests were performed, the first set was on large defects to determine the sensitivity of the tool and the second was on a specially built spool to simulate slab erosion. The large defects were created by cutting coupons out of the pipe and welding them back in a known offset from the internal pipewall. These are shown below in Figure 4.

Figure 4 Showing Defects welded back into Pipe Sample

The makeup of the defect spools was as follows:

Defect ID	Depth (mm)	Length (mm)	Width (mm)
2	1.9	610	100
5	1.9	610	150
8	2.8	610	150
11	3.8	457	150
3	4.7	610	150
6	7.62	152	150
9	0.9	152	150

The tool was pulled through this section of pipe and the data analysed to see what depth of feature could be detected by the tool. The data from these tests is shown in Figure 5 which shows the data for the whole spool and Figure 6 and Figure 7 which show close ups of individual defects.

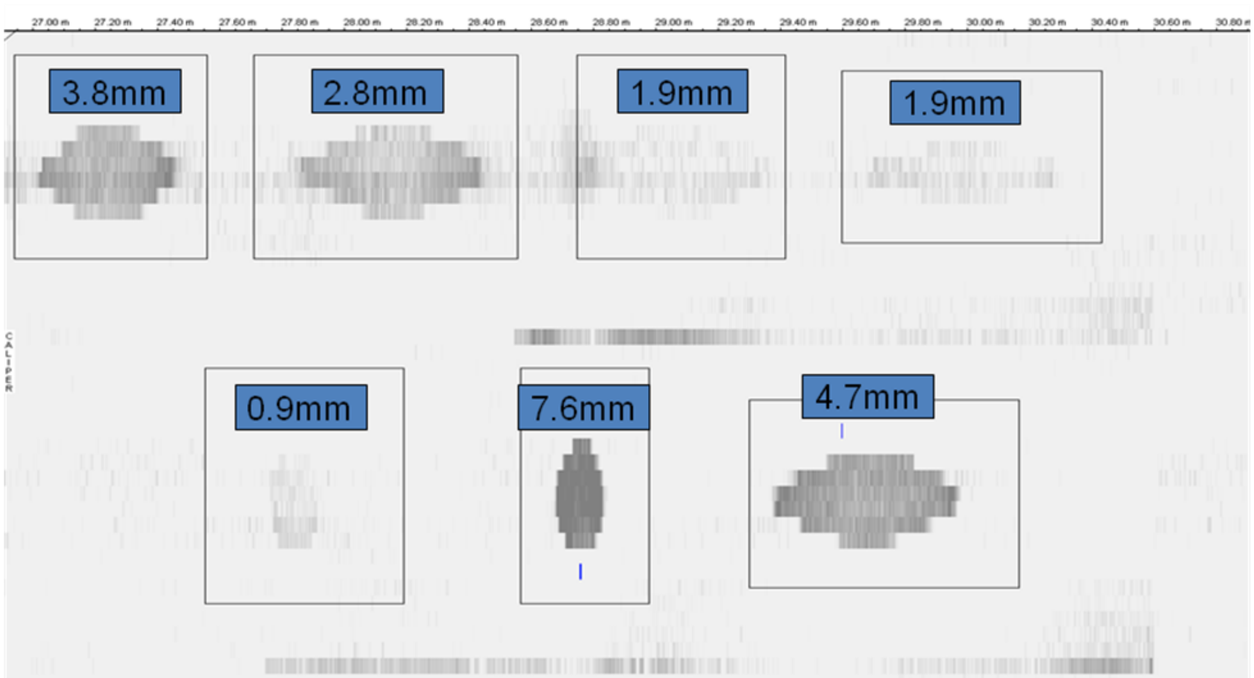

Figure 5 Showing the sensor response for the defect spool.

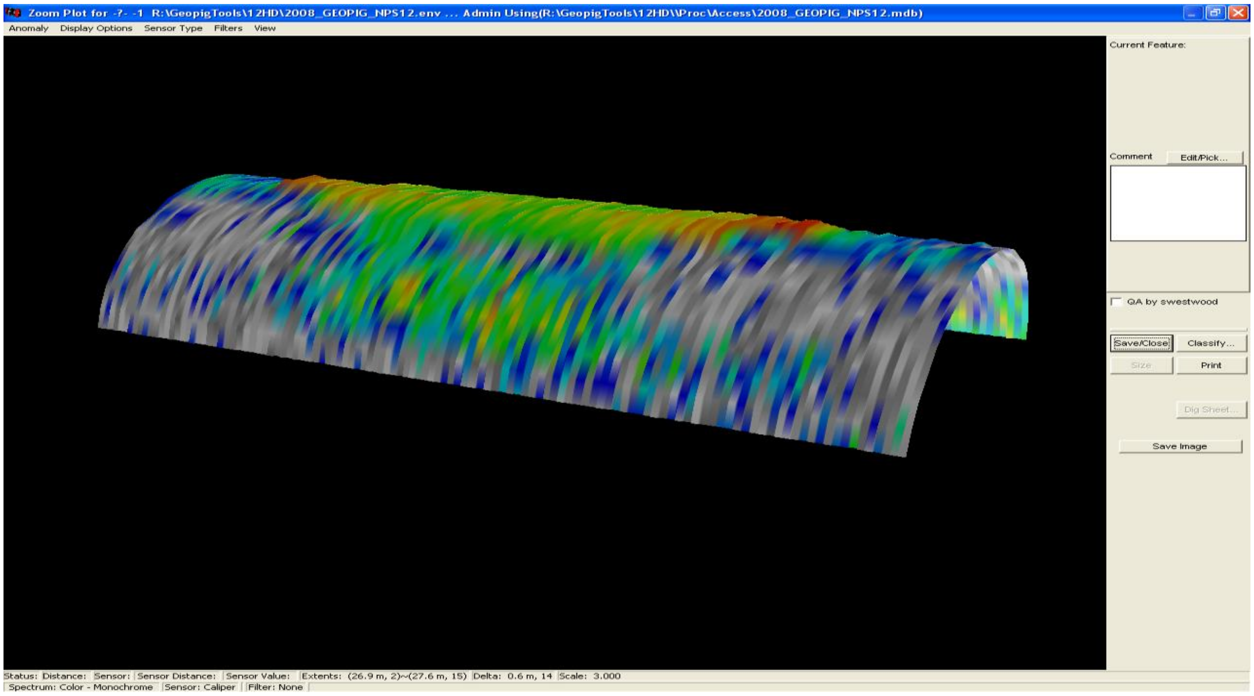

Figure 6 Sensor Response from the 3.8mm Deep defect

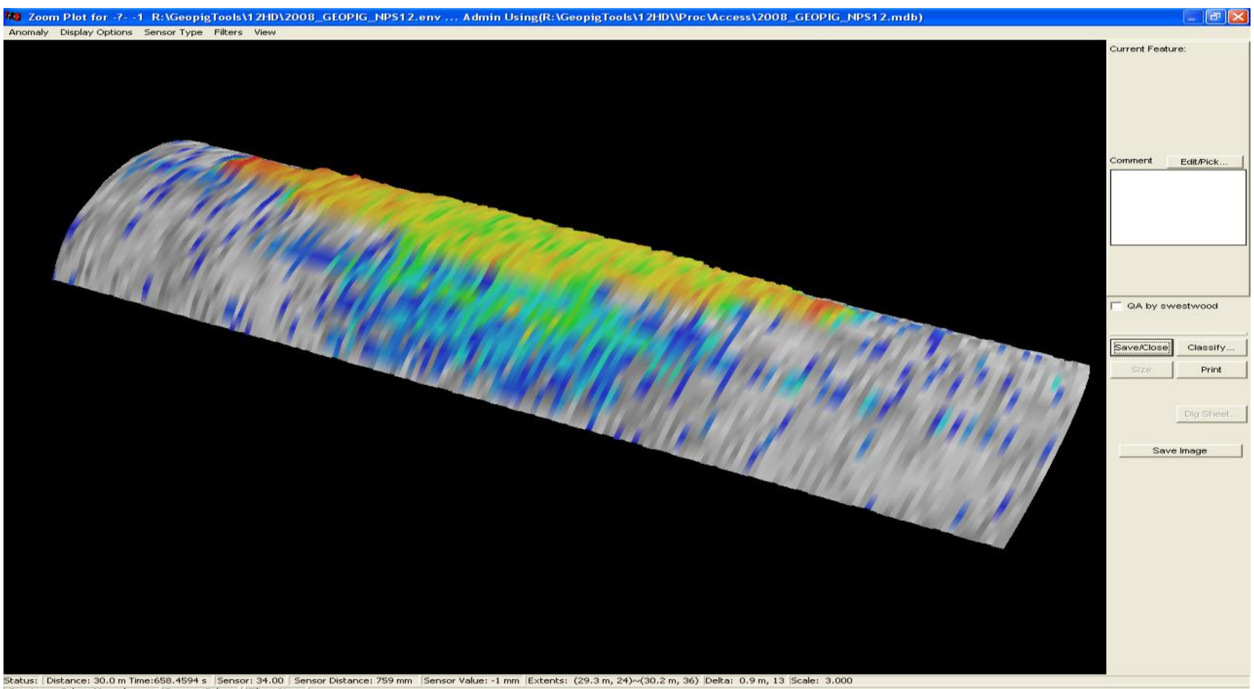

Figure 7 Sensor Response from the 4.7mm Deep Defect

These series of pulltests demonstrated the potential of a Caliper tool to size internal corrosion. However these features have sharp edges compared to the slab erosion which is gentle and can span 100's of metres. The next series of pulltests concentrated on the measurement of slab erosion and the accurate measurement of internal diameter.

To perform these tests a special test spool was constructed in 22mm 14" pipe. To mimic slab erosion a quarter section of the pipe was cut out and welded back in at a taper to simulate the internal diameter changing.

The internal diameter of the test spool was calculated by measuring the external diameter along the centreline of the tapered piece from this diameter twice the nominal wall thickness was subtracted. The variation in internal diameter along the length of the spool is shown in Figure 8. Figure 9 shows a close up of the taper.

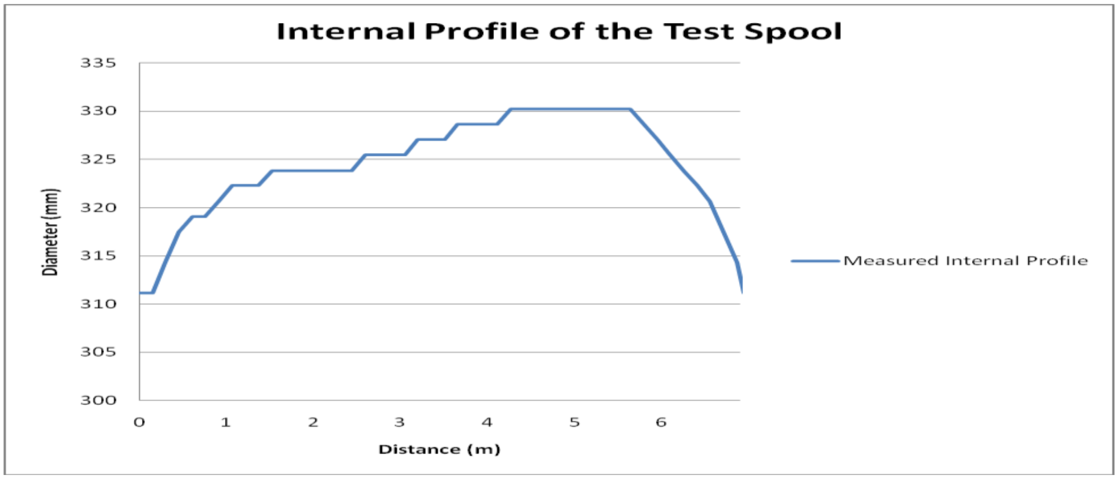

Figure 8 Measured Internal Diameter of the Defect Piece

Figure 9 Showing the Taper in the Defect Piece

The joints used in the pulltest are listed below in their order.

Pipe Order	Joint Name	Wall Thickness (mm)	Length (m)
1 (Launch)	D12-J12-W310	7.9	6.37
2	D12-J9-W380	9.7	6.02
3	D14-J14-W875	22.2	6.71
4	D12-J13-W585	14.9	5.74
5	D12-J6-W710	18.0	3.05
6	D12-J1-W365	9.3	10.88
7	D12-J5-W195	5.0	7.19
8	D12-J3-W195	5.0	6.13
9(Receive)	D12-J2-W275	7.0	9.48

Figure 10 shows the internal diameter from the GEOPIG as well as the internal diameter based on wall thickness and pipe diameter for the whole pull through. This shows very good agreement between the two values. Our measured internal diameter compared to calculated internal diameter based on pipe diameter and wall thicknesses agree within 1mm.

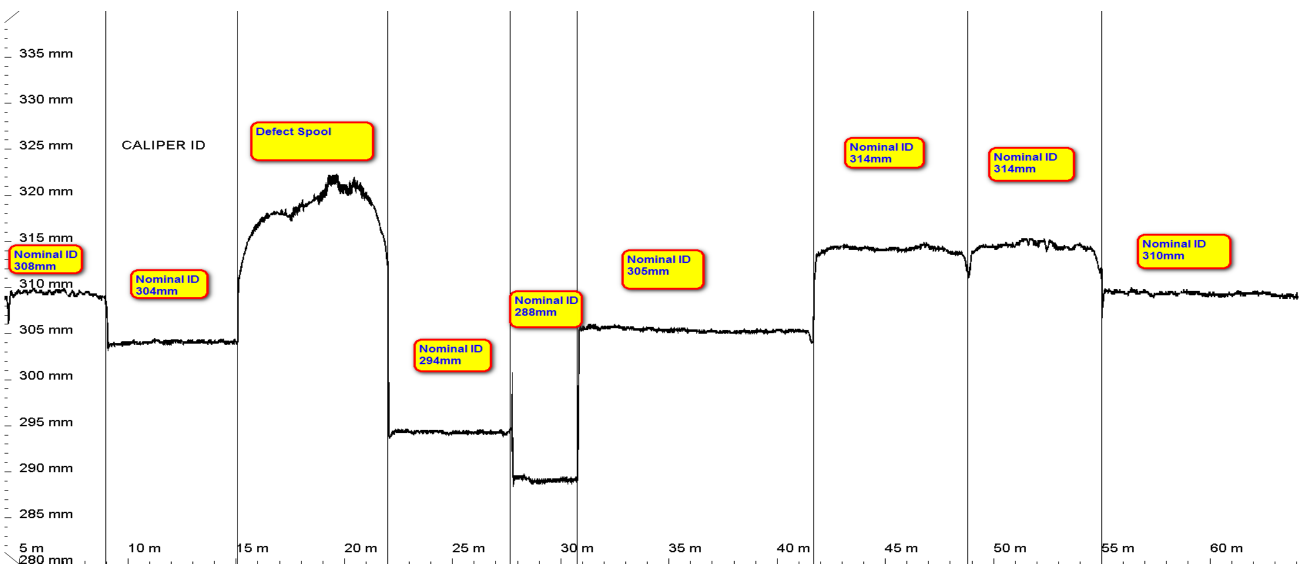

Figure 10 Comparison of Internal Diameter

The spool simulating internal slab erosion is the third joint along. The comparison between the internal diameter measured by the Geopig and the measured maximum internal diameter is shown in Figure 11

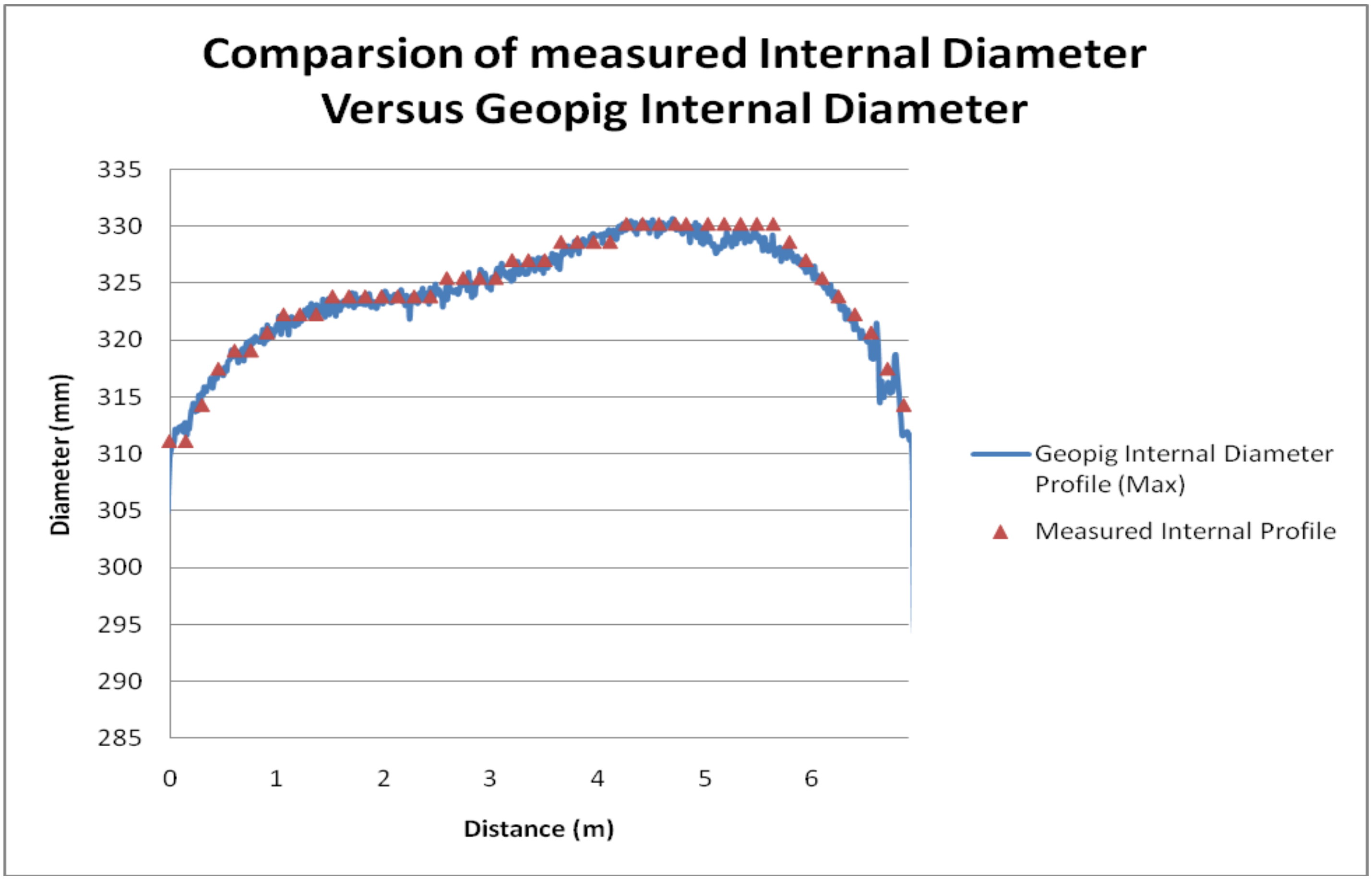

Figure 11 Comparison of the maximum measured internal diameter from the Geopig with the manually measured internal diameter

The Geopig as well as measuring the maximum internal diameter can measure the internal diameter at numerous point around the circumference of the pipe. This is illustrated in Figure 12 below which show 21 different diameter measurements along the length of the defect spool. This demonstrates the ability of the tool to accurately measure the circumferential extent of the slab erosion. The trace that is acting erratically is because that caliper arm is riding in the gap between the taper. The wiggle at 3 metres is present in the radius measurement but is cancelled in the diameter plot.

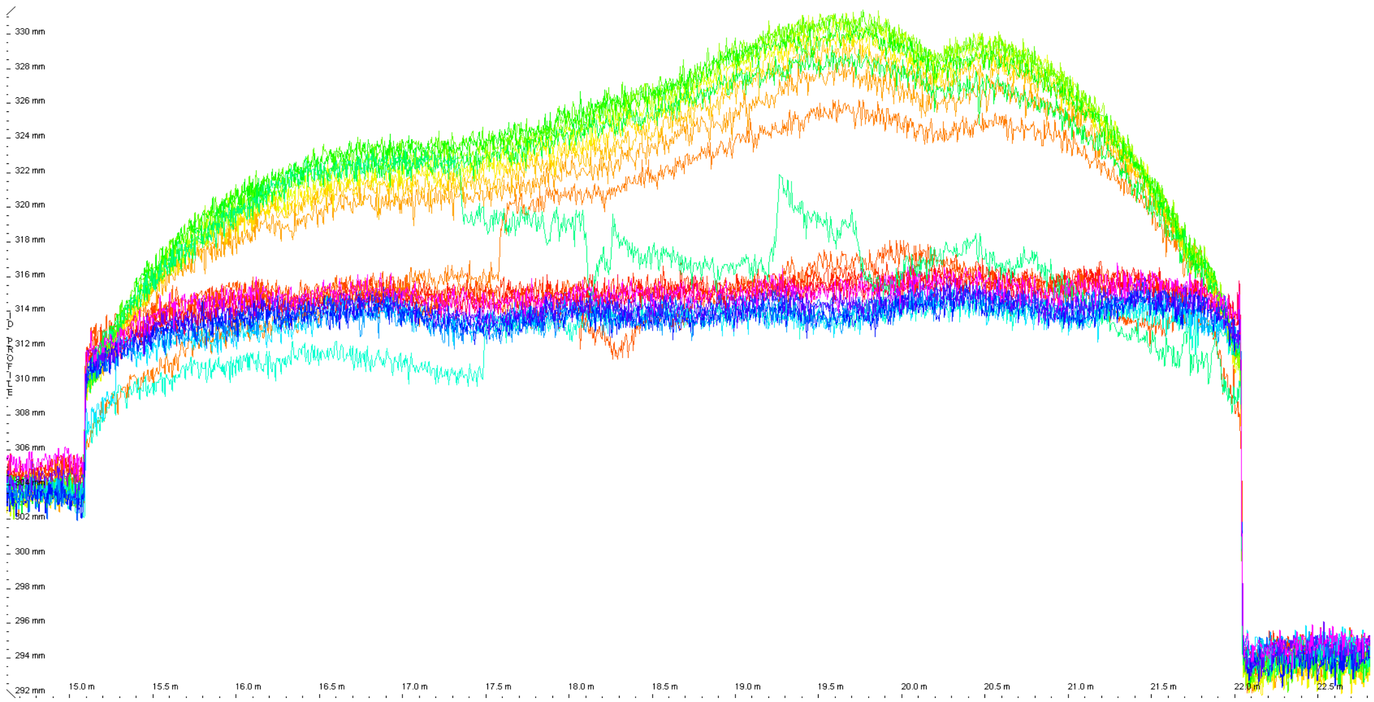

Figure 12 Illustrating the ability of the Tool to determine the circumferential extent of slab erosion

The last piece of information we wished to obtain was to determine the oclock position of the slab erosion. Previous work has been concerned with diameter, to measure diameter two caliper readings are added together, to determine the oclock position we looked at indiviual caliper sensors. This is shown below in Figure 13 , because one of the caliper arms measures close to the nominal and the other shows the size of the taper we can determine what side of the pipe the simulated slab erosion is on.

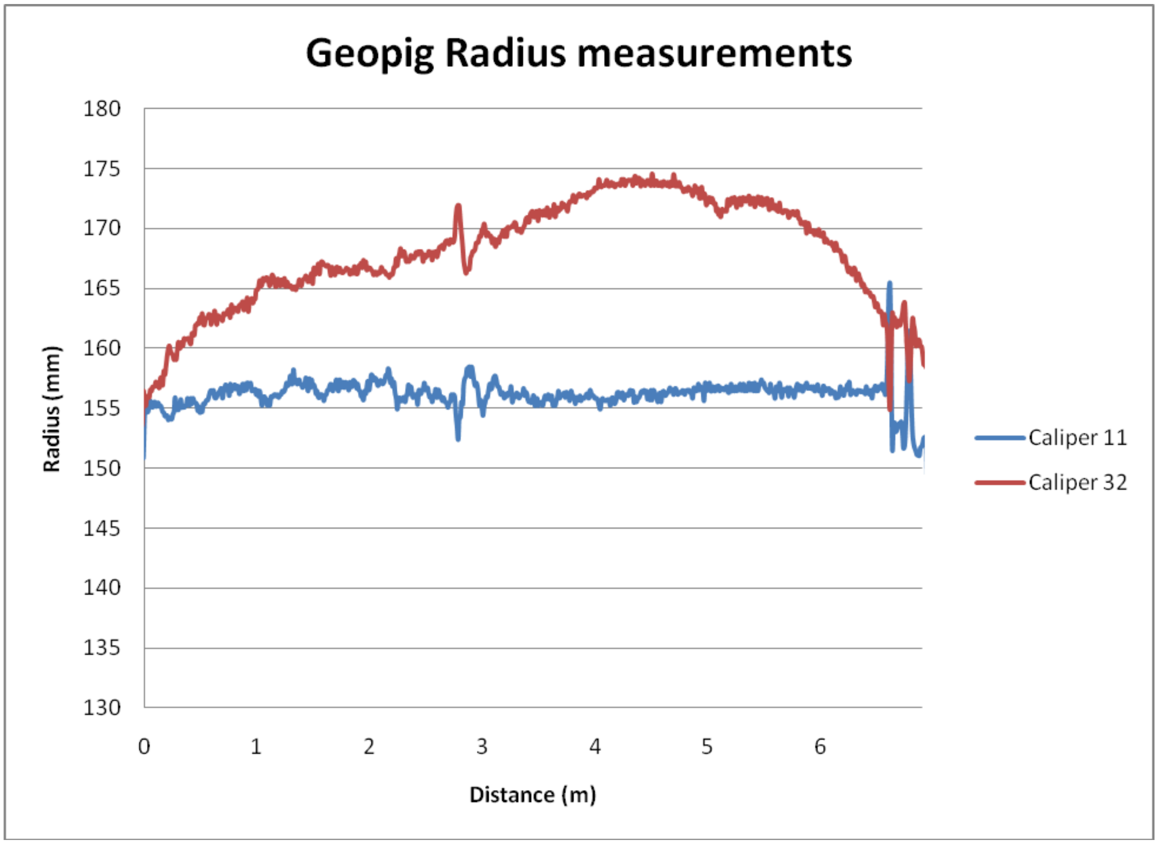

Figure 13 Demonstrating the ability of the Tool to determine the o'clock position of simulated slab erosion

Based on these positive tests, the operator decided to go ahead and schedule a Geopig inspection of the line to look for slab erosion. This was originally planned for Summer 2009 however the pigging gods have since intervened and the results from the inspection are not available as yet.

Conclusion

Through diligent post run analysis the operator identified a potential integrity threat that was not addressed by their current ILI program. Realising this they actively sought potential inspection techniques that could address this threat. The potential for a high resolution Geopig Tool to assess this type of corrosion has been demonstrated in a series of pullthroughs. The next step is to determine the performance of the tool in a real pipeline environment.

Acknowledgements

The author would like to thank BJ Pipeline Inspection Services for giving permission to present this work.